LA-UR-01-5547

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Title: Sustainable Design Report for Los Alamos National Laboratory's Strategic Computing Complex

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Introduction

Sustainable design is defined as a process for developing the built environment while considering environmental responsiveness, resource efficiency, and community sensitivity. This process includes all players, from the design team (building owners, architects, engineers, and consultants), to the construction team (materials suppliers and manufacturers, contractors, and waste haulers), to maintenance staff and building occupants.

LANL Project Team

First row (left to right): Rachel Taylor, Rose Montaño. Second row: Mark Harris, John Bretzke, Al Guerra, Laura Hanson, Steve Barret, Tom Fitzgerald, Judson Ford. Third row: Nick Nagy, Steve Day, Phil Sena, Myron Koop, Bill Bryant. Top of photo: David McBrayer

Public and private laboratory facilities, in particular, represent a great opportunity for implementing advanced, environmentally preferred building technologies and practices. The typical laboratory structure uses far more energy and water per square foot than the typical office building due to intensive ventilation requirements and other health and safety concerns. Ideally, improving the energy efficiency and environmental performance of a laboratory involves examining the entire facility from a holistic perspective.

Many positive sustainability components have been incorporated into the design and construction of the Strategic Computing Complex (SCC) at Los Alamos National Laboratory (LANL). This report summarizes those beneficial aspects of the SCC, and, hopefully, will inform, enlighten, and encourage those who are interested in achieving similar results elsewhere.

Hensel Phelps/Carter & Burgess Group

Left to right: Tim Walker-Foster, HP; Greg Collins, HP; Kable Oldham, HP; Shad Zapalac, HP; Charlie Cartwright, HP; Mark Johnson, C&B; Ken Houghton, C&B; Larry Wright, HP; Gary Johnson, HP

In evaluating the sustainability of the SCC design, the U.S. Green Building Councilís Leadership in Energy and Environmental Design (LEED) Rating Systemô has been used as a general guide. LEEDô is a system for rating new and existing commercial, institutional, and high-rise residential buildings. It is based on existing proven technology and it evaluates environmental performance from a ìwhole buildingî perspective over a buildingís life cycle. LEEDô is based on accepted energy and environmental principles, was developed with input from all segments of the building industry, and has been open to public scrutiny.

Artist's Rendering of the Strategic Computing Complex at LANL: 300,000 square-feet and three stories

The Strategic Computing Complex

The SCC is a three-story structure of over 300,000 square feet that houses the worldís largest and fastest computer. The computer itself is located in a specially designed 43,500 square-foot room that is supported by electrical and mechanical rooms in excess of 60,000 square feet. The facility is located in Technical Area 3 (TA-3) at LANL. Hensel Phelps of Greeley, CO, served as the general contractor for the SCC design and construction, as well as for the adjacent Nonproliferation and International Security Center (NISC) construction project.

The SCC is capable of simulating highly complex phenomena related to the nationís nuclear stockpile. For that purpose, the structure provides a dynamic environment for approximately 300 staff, including nuclear weapons designers, computer scientists, code developers, and university and industrial scientists and engineers, to collaborate in support of nuclear weapons stewardship requirements. These scientists and engineers work individually in private offices, and together, with support personnel, in simulation laboratories.

Computer Room at the SCC: 43,500 square-foot room will house 30 TeraOPS computer platform (viewing room is vsible at right)

The laboratories are equipped to enable complicated modeling and simulations. The technologies used include immersive theaters with virtual-reality (VR) and visionarium environments; powerwalls with the latest projection technology, conference capability, multiple display monitors, and electronic whiteboards; and collaboratories. Conference rooms and an auditorium are also provided.

The mechanical systems of the SCC are designed for maximum flexibility and the facility infrastructure is designed to be scalable. The facility will initially have mechanical and electrical equipment installed to support up to a 30 TeraOPS (trillion floating point operations per second) computer platform. As requirements go beyond the 30 TeraOPS capability, equipment can be added within the building in increments as required to support the computer technology at that time. This scalable feature of the SCC takes into account future installation of chillers, cooling towers, computer room air-conditioning units, substations, motor-generator power-conditioners, transformers, and panelboards. Scalability provides the Department of Energy (DOE) with a cost-effective option of not installing additional support equipment until it is needed and the ability to capitalize on technological advances in computing technology, as well as in the support equipment.

The computer-room cooling system is adaptable for air-cooled computers, water-cooled computers, or a combination of both types. The simulation laboratory spaces are heated, cooled, and ventilated with modular, variable-air-volume handling units. The SCC facility is fed by four different 13.2 kV underground power sources and is configured with double-ended switchgear and unit substations to allow switching for maintenance and isolation of faults. The system is modular and expandable to allow growth and easy modification. In addition to providing important cost-saving opportunities for DOE, these flexible and scalable aspects also provide means for reducing waste and increasing efficiency over the life of the complex.

Planning for Sustainability

A sustainable site is one that addresses fundamental site considerations in an environmentally sound manner. Ideally these are evaluated at the earliest planning and design stages. Among the issues considered are site selection, erosion control, minimization of ecological disturbance, reduction of heat islands and light pollution, and implementation of an effective storm water management plan. The SCC designers and builders have accommodated many of these issues in a sustainably oriented manner.

At the SCC

Limiting Environmental Disturbance

In spite of its significant size, no new ground was broken for the construction of the SCC. It was built at TA-3 within the LANL complex on a site that previously held a gas station and parking lot. Their removal and remediation was completed in 1999. In that deconstruction, some materials were stockpiled for reuse (see Materials and Resources) through the Waste Minimization/Pollution Prevention Program of Johnson Controls Northern New Mexico (JCNNM).

Old gas station and parking lot that were that deconstructed prior to SCC construction

In light of the prior history of development on the site, there were no new concerns with regard to ecological disturbance caused by construction of the SCC, and no concerns with regard to threatened or endangered species. In fact, the vegetative cover of the site has improved under the SCC design over the previous site use. Where there had been approximately 0% to 10% vegetative cover, there now is approximately 25% to 30%.

Drought-Tolerant Landscaping and Reduction of Heat Islands

The landscape structure installed at the SCC will help to reduce heat islands, and resultantly will reduce energy demands of the facility. Concrete paving used for the plaza and other pedestrian areas is lightly pigmented throughout most of the outdoor hardscape, except for some bands of darker terra cotta color. This pavement is poured-in-place concrete but all other landscaped areas incorporate a permeable ground surface (i.e. crusher fines, mulch, and grasses), allowing greater potential recharge of the groundwater table and less runoff.

Landscape design allows for reduced heat island effect and drought-tolerant plants (Courtesy of Sites Southwest)

All plants used on the property are native and/or drought-tolerant species requiring low to moderate water usage (see Water Efficiency). Plants include six native shrubs, one native tree, three non-native trees, and two exotic trees. All meadow mixes (grasses and flowers) contain native species and will require no, low, or moderate water depending on the density of the plantings desired. Two non-native but drought-tolerant perennials will also be used. In the adjacent parking lot, a non-native but drought-tolerant tree will be used to provide partial cover.

Installation of Hypalon roofing membrane

Heat island effects will be further mitigated by the installation of an Energy Star-compliant, Hypalon roofing membrane that will cover the entire SCC building. This is made of a reflective white elastomeric single-ply plastic that will sit over a polyisocyanurate insulation layer with an R-30 insulation factor. It is highly durable and has an expected lifespan of 15-20 years. When compared with gravel and black surface roofing systems over a ten-year period, the Hypalon system is estimated to save $4,900 and $8,900 in energy costs, respectively.

Stormwater Management and Erosion Control

From the initial planning phases, stormwater management has been carefully monitored in accordance with the siteís Stormwater Pollution Prevention Plan. Some temporary swales were constructed in the early stages. Once water egress points were identified, straw bales, sandbags, and silt fencing became the primary means of protecting the drainage points. These were maintained on a daily basis during construction. Storm drains carry all water leaving the site to the watershed. Similarly, erosion was controlled through the use of straw bales, silt fencing, riprap, and geocell grids. The materials that were used adhered to all state and federal guidelines and were arranged according to contour mapping of the site. After slope protection and erosion control was established, the surrounding area was graded and blended into adjacent work areas.

Temporary swales, straw bales, and silt fencing prevented erosion and stormwater pollution

Alternative Transportation

A few options are available to staff who wish to use other than single-occupancy automotive transport to and from the SCC. Shower facilities are available inside and the user will install bicycle racks outside the building. About 3% of the parking spaces will be reserved for high-occupancy vehicles and the laboratory provides a shuttle service at TA-3 that links to the Los Alamos County bus system.

Reducing Light Pollution

New Mexicoís 1999 Light-Pollution Law states that fixtures of more than 150 watts must be shielded or turned off between 11 p.m. and sunrise. Also, since January 1, 2000, mercury-vapor lamps cannot be sold or installed. The outdoor lighting at the SCC includes a variety of fixtures and lamp types. The adjacent parking lot is equipped with full cut-off luminaires and metal halide lamps. Other outdoor lighting for the building includes bollards with downward-angled louvers, wall-mounted sconces with adjustable shields, and a variety of emergency lighting fixtures. Through a programmable dimming system, timers control all outdoor lighting except for the parking lot lighting system, which is controlled by daylight-sensitive photocells. Maximum illumination for the parking lot is one footcandle (see Table 1 for a parking lot lighting efficiency comparison). No mercury vapor lamps are used for any lighting at the SCC.

Water Efficiency

In the United States, we are estimated to extract about 3,700 billion gallons of water per year more than we return to natural water systems, including rivers, streams, reservoirs, and aquifers.

However, United States (U.S.) industries today use 36% less water than they did in 1950, even though their output has increased, largely due to the reuse of water in industrial processes. Water efficiency measures in buildings can reduce water usage by 30% or more. In a typical 100,000 square foot office building, low-flow fixtures and equipment can save 1,000,000 gallons of water per year or more (based on 650 building occupants each using an average of 20 gallons per day.)

Landscape irrigation practices in the U.S. consume large quantities of potable water. High-efficiency irrigation systems can use up to 95% of supplied water compared to conventional irrigation systems that are as little as 60% efficient. Native landscapes that have lower irrigation requirements also require less fertilizer and fewer pesticides and thus reduce water quality impacts. Water-efficient landscaping also helps to conserve local and regional potable water resources for communities and future generations.

Finally, high water use increases maintenance and life-cycle costs for building operations. Monetary savings are dependent on local water costs, but some water conservation actions involve either no additional cost or a payback of less than two years.

At the SCC

Landscaping

The SCC landscaping was designed for minimal water use. The designer, Sites Southwest, expects most of the plants used at the SCC to ìnaturalizeî to the light, soil, and water regime of the area and for their water requirements to diminish over time. For some plants, no additional watering will be necessary once they have become established.

The irrigation system calls for pop-up sprinklers in the more lush areas with grass and flowers, drip irrigation for shrubs and perennials, and no irrigation in the highly drought-tolerant areas. All trees will be serviced by flood-bubblers at a low flow rate of one gallon per minute. The entire system is fully automated and will run on multiple programs to allow different watering regimes for different plant groups.

Additional waste-reducing measures for watering of plants include cobble swales on the north and east sides of the building. These will harvest and direct water to vegetation growing there. Water will also be harvested off the hardscape in the plaza area and directed to plants in that vicinity.

HVAC Water Efficiency

A design change in the cooling system from many small cooling towers to 3 large ones resulted in efficiency gains. Through this and other efficiency improvements the SCC came on-line with no additional withdrawal of water from the aquifer. Instead, treated sanitary wastewater from the LANL complex is used in the system. Initially, this will require 150 to 250 acre-feet per year of water (approximately 49 million to 82 million gallons). The amount will vary according to how clean the water is and the time of year. Approximately one year after start-up, a

	Conventional System		Efficient System		Savings	
Operation And Maintenance		**Cost**		**Cost**	**Dollars**	**Percent**
Energy cost per year		$6,412		$1,766	$4,646	72%
Maintenance cost per year		$723		$746	-$23	-3%
Total annual O&M		$7,135		$2,512	$4,623	65%
Capitol Costs	**Equipment**	**Cost**	**Equipment**	**Cost**	**Dollars**	**Percent**
Lamps	60 250W HPS	$19.20 each, $1,152 total	24 175W metal halide	$25.30 each, $605 total	$547	48%
Luminaire	60 cobra head (full cutoff); 10 1-head, 25 2-head	$246 per head, $14,760 total	24 curvilinear (full cutoff) "hockey puck" 8 1-head, 8 2-head	$585 per head, $14,054 total	$706	5%
Poles	35 poles 10 1-head, 25 2-head, all 30 feet	$732 each 1-head, $840 each 2-head, $28,320 total	16 poles, 8 1-head, 8 2-head	$900 each, $14,400 total	$13,920	49%
Installation costs (total)	Trenching, foundation, head installation, pole installation, wiring	$38,311	Trenching, foundation, head installation, pole installation, and wiring	$18,999	$19,312	50%
Total installed cost		$82,543		$48,058	$34,485	42%

Assumes 4,380 hours per year operation, $0.08 per kWh, HPS lamp life 24,000 hours, metal halide lamp life 10,000 hours, annual maintenance includes $50 per lamp spot-relamping labor.

Table 1. Economic Comparison: conventional and efficient parking lot designs

treatment facility located at TA-3 will filter the treated wastewater. This cleaning process will decrease the water demand to 90 acre-feet per year (approximately 29 million gallons), a reduction of 40% or more.

Plumbing

In accordance with the Energy Policy Act of 1992, low-flow fixtures have been installed throughout the building, including 1.6-gallon toilets and 1-gallon urinals. Also, infrared sensors are being used on all urinals and water closets in an effort to further improve water efficiency.

Energy and Atmosphere

In the United States, buildings typically consume more than 30% of our total energy and about 60% of our electricity. Combustion of fuel for building equipment produces air pollutants and on-site boilers can be significant sources of local pollution. Energy consumption and pollution can be dramatically reduced through sustainable design practices and energy cost savings pay for most energy efficient measures, often in a few years or less. Improved performance is especially achieved when measures are integrated into the design as a whole such that they are working together. For example, reduction of energy loads through improved glazing, insulation, daylighting, and use of passive solar features can enable the design team to downsize mechanical heating, ventilation, and air conditioning (HVAC) systems significantly.

A design change to 3 large cooling towers resulted in efficiency gains

According to EPA estimates, if half of the nationís approximately 150,000 private and public research laboratories achieve energy efficiency improvements of 30 percent, then the United States could reduce annual electricity consumption by 84 trillion Btuís. This figure equals the electricity consumed by 2.1 million U.S. households. This improvement would save $1.25 billion in utility costs, reduce carbon dioxide emissions by 16.4 million tons, and remove the equivalent of 3 million automobiles from U.S. highways each year. By implementing such reductions, public and private sector laboratories can achieve significant benefits including lower utility and operating costs, reduced health and safety risks, improved facility management, and reduced pollution and greenhouse gas emissions.

At the SCC

Commissioning

The contractor, Hensel Phelps, retained a third-party commissioning agent, Testmark Associates of Golden, CO. Commissioning is a process for testing a building and its energy and mechanical systems to verify that they perform as intended. Initial and on-going commissioning can optimize energy performance and efficiency by 5 % to 10% and can decrease maintenance costs. Testmark was brought on to the project in the relatively early stages (March 2000) and was able to participate in the general concept review. They reviewed and had some input into plans for chilled water schematics and sequences and mechanical/ electrical systems.

Subsequently, there were bimonthly commissioning meetings to address issues as they arose during construction, to plan coordination for building start-up, and to review safety procedures. Testmark placed two full-time staff on site to carry out standard testing procedures during construction. These have been ongoing throughout summer months. They pertained to chilled water, heating water, ventilation systems (including air handlers, variable air volumes, and exhaust fans), main switches, building substations, power boards, lighting controls, electrical receptacles, i.e. all mechanical/ electrical systems and equipment. Before Testmark completed its contract, it conducted a 24-hour baseline analysis during winter months to ensure that systems were functioning within the expected design and operating parameters. Testmarkís contract does not call for revisits. Due to security concerns, it may be necessary for LANL to carry out all future testing and recommissioning procedures. Testmark will leave behind a comprehensive procedure manual with manufacturer specifications for that purpose.

HVAC Energy Efficiency

Centralized steam from the LANL steam plant is used for heating the SCC and all resulting condensate is returned to the plant. The SCC computers generate enormous amounts of heat and a great deal of attention was given to the cooling system design. Three cooling towers, each with a 1200-ton chiller capacity, and four chillers (two 600-ton and two 1200-ton) were installed to cool the computers and the rest of the building. Chillers are regulated according to load and can be taken off-line as demands decrease.

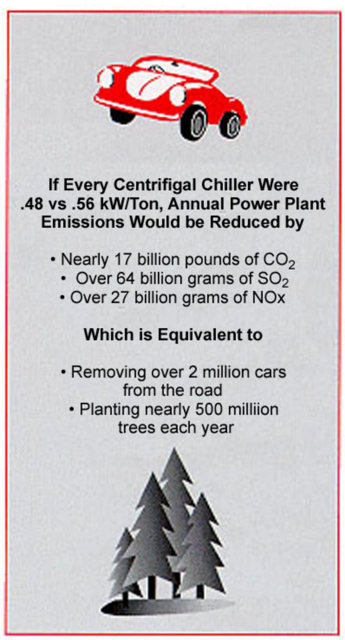
1200-ton chiller is installed

Finally, the cooling system design allows for ìfree-coolingî when outside temperatures are low, incoming water does not need to be cooled and is run directly through the heat exchangers to cool water in the loop.

Energy modeling was conducted for the mechanical system associated with the computers and fans were changed as a result. The computerís mechanical and electrical room is located beneath the computer room and serves as an under-floor return-air plenum. This allows for greater efficiency in regulating the air in the computer room than if it contained only an above-room plenum.

CFC and Halon Reduction

Under the 1987 Montreal Protocol (amended in 1992), ozone-depleting substances, such as some refrigerants (chlorofluorocarbons [CFCs]) have been phased out in the U.S. Hydrochlorofluorocarbons (HCFCs), which still contain some chlorine, will be phased out by 2030 and replaced with hydrofluorocarbons (HFCs). Refrigerants have low boiling points and evaporate at low temperatures, taking heat out of the air through vaporization and condensation.



CFCs and HCFCs are mostly associated with ozone depletion but some of these halogenated substances also act as greenhouse gases and can contribute to global warming. Halon fire retardants have also been phased out in this country due to their bromine content, an element that also damages the ozone layer.

Fossil fuels are used to generate electricity to power chillers and cooling systems throughout the world. As the adjoining figure shows, if the efficiency of every centrifugal chiller in the world were increased by only 0.08 kW/ton, power plant-generated greenhouse gas emissions would be reduced by literally billions of pounds.

Just as chillers offer varying levels of efficiency, refrigerants themselves range in efficiency. At the SCC, HCFC/R-123 is the refrigerant used to cool the building. Among refrigerants currently on the market (HCFC/R-22 and HFC/R-134a being the other commonly used products), R-123 is the most efficient. Its kW/ton rating ranges from 0.48 to 0.67, compared to 0.57 to 0.82 and 0.56 to 0.75 for R-22 and R-134a, respectively. R-123 also has the lowest ozone depleting potential (ODP) at 0.02, and the lowest global warming potential (GWP) at 93, of any HCFC. The ODP potential reflects a relative measure compared with a similar mass of CFC-11 at an ODP of 1.0. Other CFCs and HCFCs have ODPs ranging from 0.01 to 1.0. Similarly, the GWP is measured relative to the GWP of CO_2 at 1.0 and GWPs of refrigerants range from 93 to 12,100.

The indoor fire suppression system employs overhead water sprinklers. All other fire extinguishers and fire retardants being used at the SCC contain no halons or other ozone-depleting substances.

Increasing Insulation Value

Autoclaved aerated concrete (AAC) was used throughout the building. These concrete blocks are lightweight and have roughly one-fifth the density of conventional concrete. Their lighter weight reduces some of the handling costs associated with concrete construction. They are also more highly insulating than regular concrete. The blocks used at the SCC have an R-value of 12.

Lightweight autoclaved aerated concrete reduced structural steel costs by $2.5 million

The insulation value of ACC is climate-dependent. In Los Alamosí dry climate, where temperatures fluctuate significantly throughout the day, the SCC will benefit from the thermal lag effect of AAC, which reduces heat movement between the interior and exterior of the building. This material has been shown to significantly reduce energy costs when compared with conventional concrete blocks. With an additional two-inch fiberglass insulation (R-7) behind the concrete, the walls have an R-19 insulation rating throughout the SCC. Furthermore, using lightweight AAC allowed for the savings of $2.5 million in structural steel.

For security purposes, the offices and workspaces are located at the interior of the building and are surrounded on all sides by halls and corridors. These corridors act as a further insulating air space to the benefit of the interior work areas. Triple-pane tinted windows lining the halls also provide high insulation value by reducing heat loss or gain through the buildingís glazing.

Variable-Frequency Drives and Variable Air Volume Controls

Motors are used for various applications in buildings including ventilation, cooling, and vertical transportation. Typically, motors used to drive the requisite fans, compressors, and pumps in commercial buildings account for about 23% of all electricity consumed. Using efficient components such as premium efficiency motors and variable-speed drives, also known as variable-frequency drives (VFD), can reduce energy use of the motor-driven system by 10% to 50% or more, depending on how much the entire system is taken into account in the design. Also, because a motor often consumes energy worth about 10 times its initial cost, any extra costs associated with purchasing more efficient components can usually be recovered within the first few months of operation.

Standard induction motors are designed to run at a fixed speed. Using motor controls that allow greater variability and flexibility in regulating fans and pumps can provide substantial energy savings. A VFD is an electronic device that provides power at varying frequencies making it possible for induction motors to operate at anywhere from 10% to 300% of their nominal fixed speed. VFDs are applied in variable-air-volume (VAV) air handling systems with very positive results as well. For example, a variable-flow, chilled water pumping system in a typical large office building will often consume only 30% to 50% of the energy consumed by a constant-flow system.

The SCC's energy and mechanical systems are controlled through a single computer terminal

Materials and Resources

Construction and demolition waste makes up approximately 25% of the solid waste stream in the U.S. It is also estimated that typical commercial office buildings generate 1 pound (lb.) of solid waste per 100 square feet per day (this would mean 3,000 lbs. per day for the SCC) (see Table 2). Many of the materials in this waste stream can be reused or recycled. In constructing a building, products can also be selected based on their recycled content and reusability. Other important considerations in selecting building materials include whether they were produced in a sustainable way. Sometimes referred to as ìenvironmentally preferred products,î such materials are important for their recycled content, rapid renewability, durability, and low embodied energy (i.e. the total amount of energy used to produce a product). It is also important to consider whether the choice of materials, and other resources and services, supports the local economy.

Building Basis	
Office Building	1 lb. / 100 sq. ft. per day
Warehouse	1.5 lbs. / 100 sq. ft. per day
University	6 lbs. / room per day
Person Basis	
Large Federal Office Building	2.9 lbs. per employee/day
University	0.25 lbs. per pupil/day
Construction and Demolition Waste	**Percentage by Volume**
Wood	27.4
Asphalt, concrete, brick, dirt	23.3
Drywall	13.4
Roofing	12.0
Metal	8.8
Paper	2.7
Miscellaneous	11.9

Table 2. Solid Waste Facts

At the SCC

Supporting the Local Economy

Hensel Phelps, in consultation with LANL, set a goal of meeting at least 10% of their subcontractor and supplier needs through businesses located in the northern eight counties of NM. Hensel Phelps actively pursued local companies and solicited bids and proposals from them. The actual percent of contract work provided by northern NM companies reached 15%. Purchasing materials and services locally not only promotes the local economy, but also reduces environmental releases resulting from transportation.

Diverting Solid Waste from the Landfill

As already mentioned, construction activities generate large quantities of solid waste. Approximately two pounds of waste is generated per square foot of commercial construction and much of it is reusable or recyclable. Asphalt, concrete, brick, and dirt make up an estimated 23% of construction and demolition waste by volume.

At the SCC, all uncontaminated asphalt and soil collected during the deconstruction of the original site structures and pavement was stockpiled for reuse elsewhere at LANL. This amounted to 2,600 tons of asphalt and 34,000 cubic yards of soil. The asphalt was ground up for reuse as base course material in future paving, and the soil will be reused as fill material at other LANL construction sites. Also throughout construction, cardboard was segregated and sent for recycling.

Storage and Collection of Recyclables

By making recycling convenient for occupants, a large proportion of a buildingís routine waste stream can be diverted from landfills (see Table 3). LANL has an extensive recycling program. It includes paper and fiber products, glass, plastics, metals, batteries, oil

Recyclable Material	Percentage by Volume
High-grade paper	39.6
Low-grade paper	20.2
Glass	11.8
Other paper	7.4
Newsprint	7.0
Food waste	2.9
Cardboard	2.8
Plastic	2.6
Metal	1.8
Other	3.9

Table 3. Recyclables

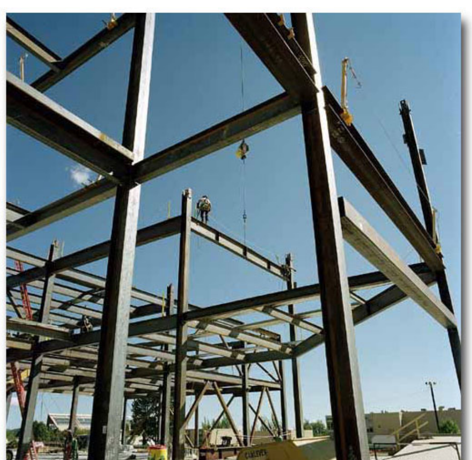
Soil was collected during deconstruction and stockpiled for reuse

products, junk mail, construction debris, office supplies, and a chemical exchange program. Collection receptacles have been provided at the SCC in accordance with LANL recycling practices used elsewhere in the complex.

Choosing Materials that Promote Sustainability

The use of AAC (see Energy and Atmosphere) allowed a savings of $2.5 million in structural steel due to the lightness in weight of AAC blocks. AAC is also recyclable. The particleboard used in the building is made from 100% recycled and recovered wood fiber. The recycled content of the ceiling tiles ranges between 37% and 48% and they are reclaimable by the manufacturer. The steel for the ceiling suspension system contains 25% recycled content. The boards inside the acoustical wall treatments contain approximately 50% recycled content and are recyclable. The polyisocyanurate insulation that was installed beneath the Hypalon roofing membrane meets the U.S. Environmental Protection Agency (EPA) requirement of at least 9% recycled content.

As for structural steel used in the SCC, it contains the greatest postconsumer recycled content of any material in the building. All steel is completely recyclable and all newly manufactured steel contains recycled content. The amount of recycled content depends on the technology used to produce it. The basic oxygen furnace (BOF) process, which is used to manufacture things like soup cans, car fenders, storage drums and appliance encasements, uses 25% to 35%



Structural steel contained almost 100% recycled content, 59% postconsumer

recycled steel. Nationwide, in the year 2000, this steel contained about 32% recycled content and the post-consumer proportion of that steel amounted to about 20%. The electric arc furnace (EAF) process, used for making things like structural beams, steel plates, and reinforcement bars, uses nearly 100% recycled material. Nationwide, for 2000, this steel contained about 96% recycled content with a post-consumer proportion of 59%. The percentages for steel used in the SCC are comparable.

All four of the carpet products being used in the SCC are made with type 6,6 nylon fibers, which are more resistant to staining, crushing, and matting. This carpet therefore has a longer lifespan than polyester or polypropylene carpet. The carpet fiber and carpet backing contain no recycled content but all the material is recyclable. There is no cushion used under the carpeting.

Ceramic wall tiles are used in the bathrooms. These contain recycled content ranging from 6% to 11% and averaging 8%. The insulation used to insulate roofing sealant from high and low temperatures contains a minimum of 10% recycled content. Thermal Shieldô noncombustible fiberglass wall insulation containing a certified 25% minimum recycled glass content was used throughout the building.

Approximately 50% of the furniture used in the SCC comes from Herman Miller, Inc. Herman Miller has received environmental awards in the areas of waste reduction, product design and business practices, and recycling. It was also cited by Fortune 500 magazine as being one of the nationís 10 most environmentally responsible corporations. Herman Millerís environmental program covers numerous areas including the recycled content of fabrics and other materials, reductions in energy use, use of water-based stains and sustainable woods, implementation of efficient packaging processes, and reduction of volatile air emissions.

Indoor Environmental Quality

On average, U.S. residents spend 80% to 90% of their time indoors. As a result, the quality of the indoor environment has a significant influence on health, productivity, and quality of life. Studies have shown that indoor environmental quality (IEQ) improvements can increase worker productivity by as much as 16%, leading to rapid payback for IEQ investments. IEQ generally includes issues related to indoor air quality (IAQ) such as effective ventilation and control of contaminants, and illumination and acoustics issues, but can also include other things like thermal comfort and flexibility, views, and the arrangement of workspaces.

At the SCC

Thermal Comfort

SCC occupants enjoy a highly flexible climate control system. There are separate thermostats and variable-air-volumes located in each office, and hallways also have independent temperature controls. As mentioned above, the SCCís insulation value (R-19) and triple-paned windows contribute significantly to energy efficiency and to the comfort of occupants.

Triple-paned windows provide thermal efficiency and natural lighting

Low-Emitting Materials

Many building products contain compounds that have a negative impact on indoor and outdoor air quality. The most prominent of these, volatile organic compounds (VOCs), are chemical compounds that react with sunlight and nitrogen to form ground-level ozone, a chemical that has detrimental effects on human health, agricultural crops, forests, and ecosystems. Ground-level ozone damages lung tissue and is a major component of smog.

Many low-VOC emitting materials were used in the SCC construction, which provided some benefit to the construction staff. Through the commissioning process, the entire SCC building was also ventilated when all fans were brought on-line for testing prior to occupancy, helping to further limit exposure of building users to VOCs.

Fifty percent of the paints and coatings used in the building contain VOC levels that meet or exceed the limits required by the LEEDô Rating System, which is more stringent than federal or state guidelines. Four of the paints (all Health Spec brand) contain no VOCs at all. These were used on office and corridor walls and doorframes, amounting to approximately 17% of the interior space. One of the sealants used in the roofing system contains VOCs at a concentration less than or equal to 65 g/L, well below the LEEDô guideline. The carpet adhesive used throughout the building contains no VOCs.

Decorative panels and laminates used at the SCC meet or exceed the federal guideline for formaldehyde (i.e. less than or equal to 0.3 ppm), and the adhesives used to fabricate these products contain low or no VOC content. The particleboard used in the SCC contains formaldehyde but releases do not exceed the 0.3-ppm limit and they do not contain VOCs. All four carpet products being used in the building meet the Carpet and Rug Instituteís green label guidelines for low or no VOCs.

Lighting

Lighting is one of the most significant IEQ components. There are numerous studies underway seeking to accurately measure effects of lighting on worker productivity. Improvements in productivity as a result of energy efficient, high quality lighting are currently estimated to range from 6% to 16%. Good lighting also brings other important benefits such as reduced eye strain, improved visual quality of the work environment, and increased energy efficiency.

A buildingís lighting system and design should be evaluated for certain criteria. These include optimum quantity of lightóit is possible to have too much light, especially from an energy cost standpoint (see Table 4). Good light quality is also important, and is measured using such parameters as coordinated color temperature (CCT), color rendering index (CRI), and lamp flicker. Lighting efficiency is determined mainly by ballasts, lamps (i.e. lamp lumen depreciation [LLD]), and the number of lamps each ballast can accommodate.

	Baseline (High Level)	Improved (Medium Level)
Lighting System		
Design Lighting level (footcandles)	50	30
Luminaire quantity	150	90
Luminaire power (watts)	60	60
Total Power (watts)	9,000	5,400
System Economics		
Run time (hours per year)	2,000	2,000
Total system power density (watts per square foot)	0.9	0.54
Energy consumption (kilowatt-hours per year)	18,000	10,800
Operating cost ($/year)	$1,800	$1,080
Savings ($/year)		$720
Savings (percent)		40%

Assumes two-lamp T8 recessed ceiling troffer with electronic ballast; 10,000 square-foot area; electricity cost of $0.10 per kilowatt-hour.

Table 4. Cost/Energy Savings of Medium Light-level Design Compared to Typical High Light-level System

The SCC used a combination of fluorescent, metal halide, high pressure sodium, and incandescent lamps to achieve an efficient and effective lighting regime for the SCC interior and surrounding areas. Fluorescent lamps are efficient and have long lamp lives. They provide three times the lumens per watt of incandescent lights. High-pressure sodium lamps are comparable in lumens to fluorescent lamps and more efficient than metal halide lamps. Electronic, high-frequency ballasts were used throughout the building and provide increased energy efficiency and lower operating costs. They are more efficient than magnetic ballasts and are estimated to result in an overall efficacy (lumens per watt) increase of 15% to 20%, while consuming up to 30% less power. Other advantages of electronic ballasts include their lighter weight, quieter operation, faster start-up times, and reduced lamp flicker. Forty-three percent of all luminaires at the SCC use electronic ballasts that operate three or four lamps, rather than one or two. This allowed the use of a single ballast in 3-lamp and 4-lamp luminaires, thereby reducing both installation and field wiring labor costs.

Town central and kitchen areas offer views and daylight

The interior of the SCC is equipped almost entirely with fluorescent lighting. Approximately 70% of the lamps used are Philips ALTO low-mercury fluorescent lamps. Most of those are 32-watt triphosphor bulbs with a good CRI of 78, adequate for graphic or other detailed work. They have a CCT of 3500 Kelvin, which provides a middle level between ìcoolnessî and ìwarmthî and that works well in a range of illuminances. Generally, this lamp also has a lower LLD than other fluorescent lights, meaning it maintains fairly steady performance over time. Tri-phosphor lamps have a coating on the inside that provides even better performance and CRI values. These ALTO lamps also incorporate rapid-start technology, which reduces lamp flicker.

All offices are equipped with motion sensors and 3-way wall switches for adjusting light levels. Motion sensors provide estimated energy savings of 25% to 50% for offices and 45% to 65% for conference rooms. Motion sensors can reduce lamp life, but less so in conference rooms and other low-traffic areas. Dimmable fixtures are provided in all conference rooms, the auditorium, and the immersive and powerwall laboratories. The ceiling tiles have a relatively high light reflectance factor of 0.84, which will help disperse light more evenly throughout the rooms. Uplighting, which also diffuses light indirectly through a room, will provide 95% of the light in all conference rooms, collaboratories and computer classrooms. Large atriums will reduce the need for artificial lighting in corridors and will draw light to some of the interior office spaces.

Daylight, Views, and Efficient, Comfortable Workspaces

The building uses fully enclosed offices that offer privacy and quiet. The ceiling tiles have a fairly high noise reduction coefficient of 0.70, which will help reduce ambient noise throughout the building. Offices contain numerous electrical outlets, reducing the need for power cords and providing increased convenience. Town central areas and kitchen facilities have been provided for group interaction in well day-lit areas of the building and they offer views of the surroundings. Break rooms are adjacent to hallways and will receive consistent daylight. The room numbering system makes it easier for people to find each other than is sometimes possible in government buildings. Showers

Looking west at the strategic computing complex and the foothills of the Jemez Mountains

have been installed for the benefit of the staff and will facilitate the use of bicycle transportation to and from work.

The SCC—A Good Starting Point

The SCC stands as an exciting and hopeful example of what can be achieved in contemporary building design and construction. The building was not conceived or pursued specifically as a sustainable design, ìgreen-builtî project and yet so much of what was incorporated meets some of the highest standards and guidelines promoted in the green building industry and established by state and federal regulatory bodies. There are outstanding features among the materials and systems that constitute a significant portion of the infrastructure of the SCC. Autoclaved aerated concrete, Health Spec paints, ALTO fluorescent lamps, low-water cooling system, under-floor plenum, motion sensing lights, and variable frequency drivesóthese offer significant gains in energy savings, air quality, water efficiency, and indoor environmental quality over conventional building design and construction.

The resources required to maintain our nationís present level of infrastructure are enormous, yet those resources are diminishing. To remain competitive and effective, the building industry, and its clients and partners in government, must address these changing economic and environmental conditions. The achievements of the SCC project serve to move the sustainable building industry forward with creative market-based solutions. The innovations employed at the SCC contribute environmental, economic, and social benefits that can be enjoyed by builders, occupants, and the general public alike.